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Introduction

JUDY PENTTILA
AMBROSE JEARLD, JR.
STEVE CLARK
Woods Hole Laboratory
Northeast Fisheries Center
National Marine Fisheries Service, NOAA
Woods Hole, MA 02543

The ability to perform age determinations based on examinations of hard anatomical parts is of fundamental importance in fisheries research. As for trees, for which an age may be determined by counting annual rings in a cross section of the trunk, certain structures of finfish and bivalve molluscs taken from temperate waters also show alternating structural marks caused by changes in growth rates. Validation of a regular periodicity in these marks permits assigning a time scale and determination of age. The successful application of techniques to enhance detection of age marks in biological specimens is of vital importance in estimating growth and mortality rates, population age structure, and other parameters needed for understanding the dynamics of fishery resources and their response to natural phenomena and exploitation.

A wide variety of age-determination techniques have been developed for finfish and bivalve molluscs which depend on detection of contrasting bands in body parts such as scales, otoliths, fin rays, spines, and bones of fish, as well as external and internal structures of mollusc valves. At the Woods Hole Laboratory, such studies have been conducted for decades and a considerable body of information has been compiled for a variety of Northwest Atlantic species. In many cases, however, these methods have not been formally published (or were published in an incomplete form). The purpose of this manual is to document the techniques used by staff at Woods Hole for researchers dealing with similar species and problems in other regions.

A brief history of the various investigations and units responsible for age assessment at the Woods Hole Laboratory is given as background information. The Laboratory was first established in 1885, although studies of age and related research was fairly limited in the early years. The Laboratory was closed during World War II, and significant progress on age research did not resume until the Laboratory was reopened in 1947 and the North Atlantic Fishery Investigation of the Fishery Biology Branch, U.S. Fish and Wildlife Service, was established. Groundfish resource surveys were initiated to investigate the biology and resource potential of various fish stocks, with age reading conducted within "species" investigations by project leaders and their scientific aids and technicians. Age determinations for most species, however, were sporadic and were completed to answer specific research needs at the time, in contrast to a sustained production mode which has been characteristic of more recent years. Development and validation of techniques concurrently supported programs of the International Commission for the Northwest Atlantic Fisheries (ICNAF) which was organized in 1951 for the management of the groundfish fisheries of the Northwest Atlantic. Age determination studies conducted from 1951 through 1964 focused on haddock (*Melanogrammus aeglefinus*), redfish (*Sebastes fasciatus*), Atlantic herring (*Clupea harengus*), silver hake (*Merluccius bilinearis*), yellowtail flounder (*Limanda ferruginea*), Atlantic cod (*Gadus morhua*), scup (*Stenotomus chrysops*), summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), and Atlantic sea scallops (*Placopecten magellanicus*).

In 1965, species investigations at the Laboratory were aggregated into the Population Dynamics Program and a separate age determination unit was established. The work of the program involved collection of catch information, processing and determining the age of biological specimens, automatic data processing, and research on vital statistics, yield, and population processes. The new Age Reading Unit initiated routine ageing of haddock and yellowtail flounder and conducted preliminary studies from 1965 to 1970 to develop and validate ageing techniques for species such as fourspot

flounder (*Paralichthys oblongus*), American plaice (*Hippoglossoides platessoides*), red hake (*Urophycis chuss*), and pollock (*Pollachius virens*). Experiments with staining otoliths were also conducted. Some species (e.g., redfish and Atlantic sea scallops), however, were still aged by individual investigators in other units.

During the early to mid-1970's many new techniques for preparing structures for age determination were developed, e.g., thin-sectioning and baking otoliths, and using laminated plastic for scale impressions. The number of species routinely examined for age (i.e., in a production type of mode) gradually increased through the 1970's to a current total of 18, and methods for an additional ten species have also been developed.

In 1978, the Fishery Biology Investigation was created. Currently, the Investigation is part of the Conservation and Utilization Division (CUD) of the Northeast Fisheries Center (NEFC). The primary function of the Investigation is to provide biological information required for assessing the status of selected fishery resources, including population age compositions, mortality and maturation rates, growth and fecundity parameters, and physiological and behavioral characteristics.

Major emphasis, however, is on routine assessment of age for 45,000 to 50,000 specimens, representative of commercially and recreationally important finfish and bivalve molluscs in the Northeast region. Current studies focus on growth analyses; age validations; development of new and more cost-efficient methods; studies of size and age at sexual maturity; automatic image analyses of age structures (Cambridge Instrument Company, Inc. 1980), including optical Fourier transform analyses for stock identification (Almeida et al. 1987); and examination of daily growth increments on larval otoliths (Jearld 1983, Campana and Neilson 1985).

This manual describes methods currently in use for biological sample preparation and age determination of most finfish and bivalve species for which the Investigation has responsibility. The various techniques used for preparing anatomical structures are described as well as criteria used to interpret growth patterns and to assign ages. Many of these methods and criteria have not been formally validated and must be considered "experimental." The age determination process consists of the following steps: collection and storage of age samples, preparation of structures for age determination, examination, interpretation, and assessment of the validity and reliability of the resulting data. Most specimens examined are from samples taken during routine NEFC bottomtrawl and shellfish resource surveys; specimens from commercial landings are, however, also collected at dockside by NEFC port samplers.

The first part of this manual contains general information on processing specimens for age determination and a glossary of terms. The remainder of the manual describes specific procedures developed for individual species. The species descriptions include information on biology and distribution; former studies of age and structures used for age determinations; sample storage, preparation, and methods of examination; and descriptions of growth patterns and problems related to age determination.

Table 1 lists the species considered in this manual, the age structure examined, specimen preparation method generally in use, average number of specimens aged each year (if the species is aged routinely), and the time series available in each case.

Note: In the figures for all sections which follow, black dots indicate annuli; black dashes indicate checks, splits, or false annuli.

Table 1

Age structures, preparation methods, average number of specimens examined each year, and time series of available data for species included in this manual.

Species	Age structure	Preparation method	Average number aged/year	Year samples first collected[1]
Atlantic herring	otoliths	embedded	4,800	1973
Haddock	scales	impressions	3,500	1931
Atlantic cod	otoliths	baked	4,450	1960
Pollock	otoliths	sectioned	2,550	1966
Silver hake	otoliths	sectioned	2,750	1955
Red hake	otoliths	sectioned	1,450	1964
Black sea bass	otoliths	sectioned	none	1980
Weakfish	scales	impressions	none	1978
Atlantic mackerel	otoliths	embedded	2,200	1973
Butterfish	otoliths	whole	2,550	1964
Redfish	otoliths	sectioned	2,500	1964
Summer flounder	scales	impressions	3,300	1974
Winter flounder	scales	impressions	3,250	1973
Witch flounder	otoliths	sectioned	1,450	1973
American plaice	otoliths	sectioned	3,200	1971
Yellowtail flounder	scales	impressions	5,500	1955
Surf clams	chondrophore	sectioned	2,950	1978
Ocean quahogs	valve	acetate peels	50	1978

[1]In each case, sampling has been continued to the present.

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Citations

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